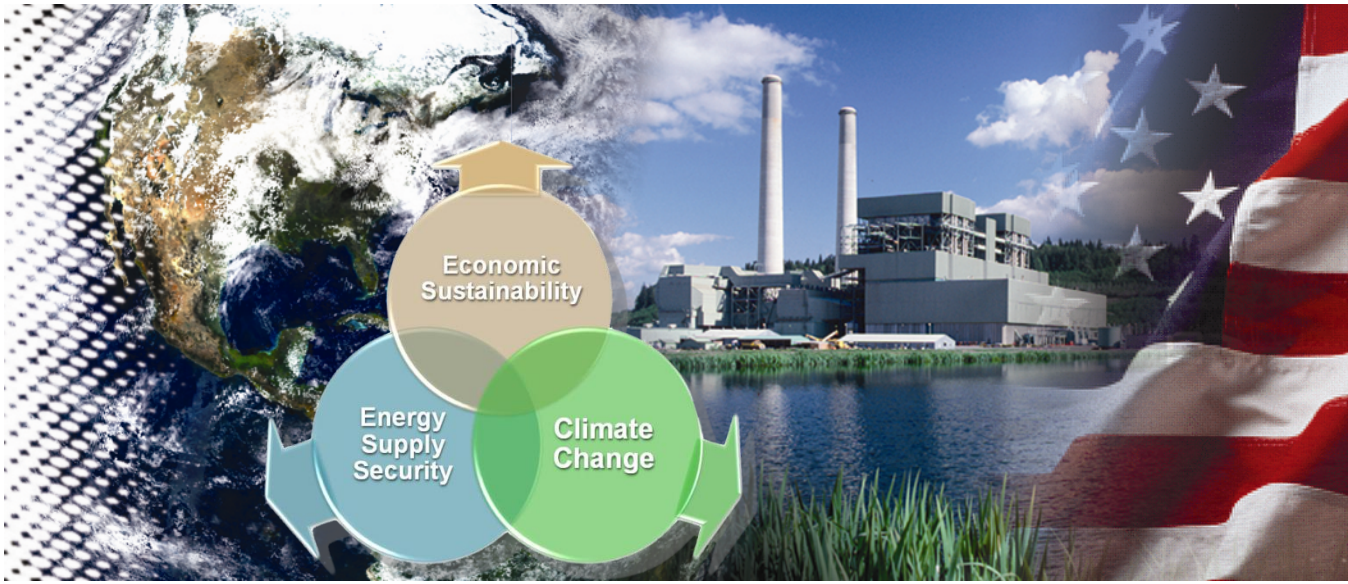
NATIONAL ENERGY TECHNOLOGY LABORATORY

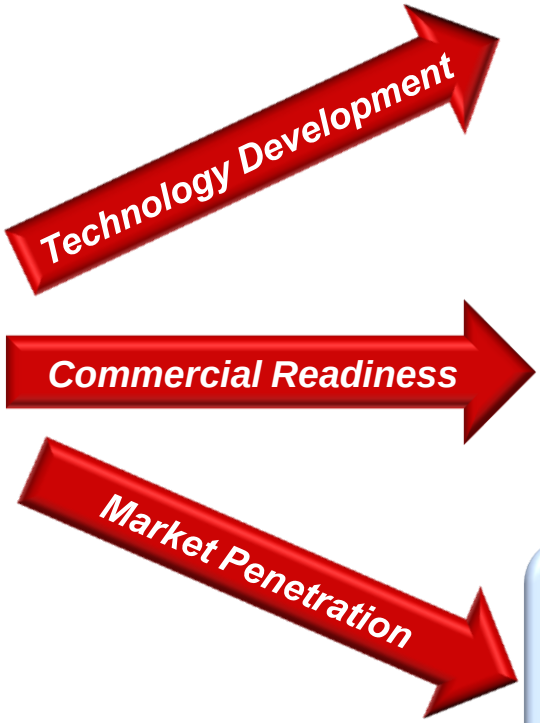


DOE/NETL Major Demonstration Program Update

Greg O'Neil
National Energy Technology Laboratory
Office of Major Demonstrations

U.S. DEPARTMENT OF ENERGY

Government's Coal RD&D Investment Strategy



Programs

RESEARCH & DEVELOPMENT

Core Coal and
Power Systems R&D

DOE – FE – NETL

TECHNOLOGY DEMONSTRATION

Clean Coal Power Initiative
Stimulus Activities

DOE – FE – NETL

FINANCIAL INCENTIVES

Tax Credits
Loan Guarantees

DOE – LGO – IRS

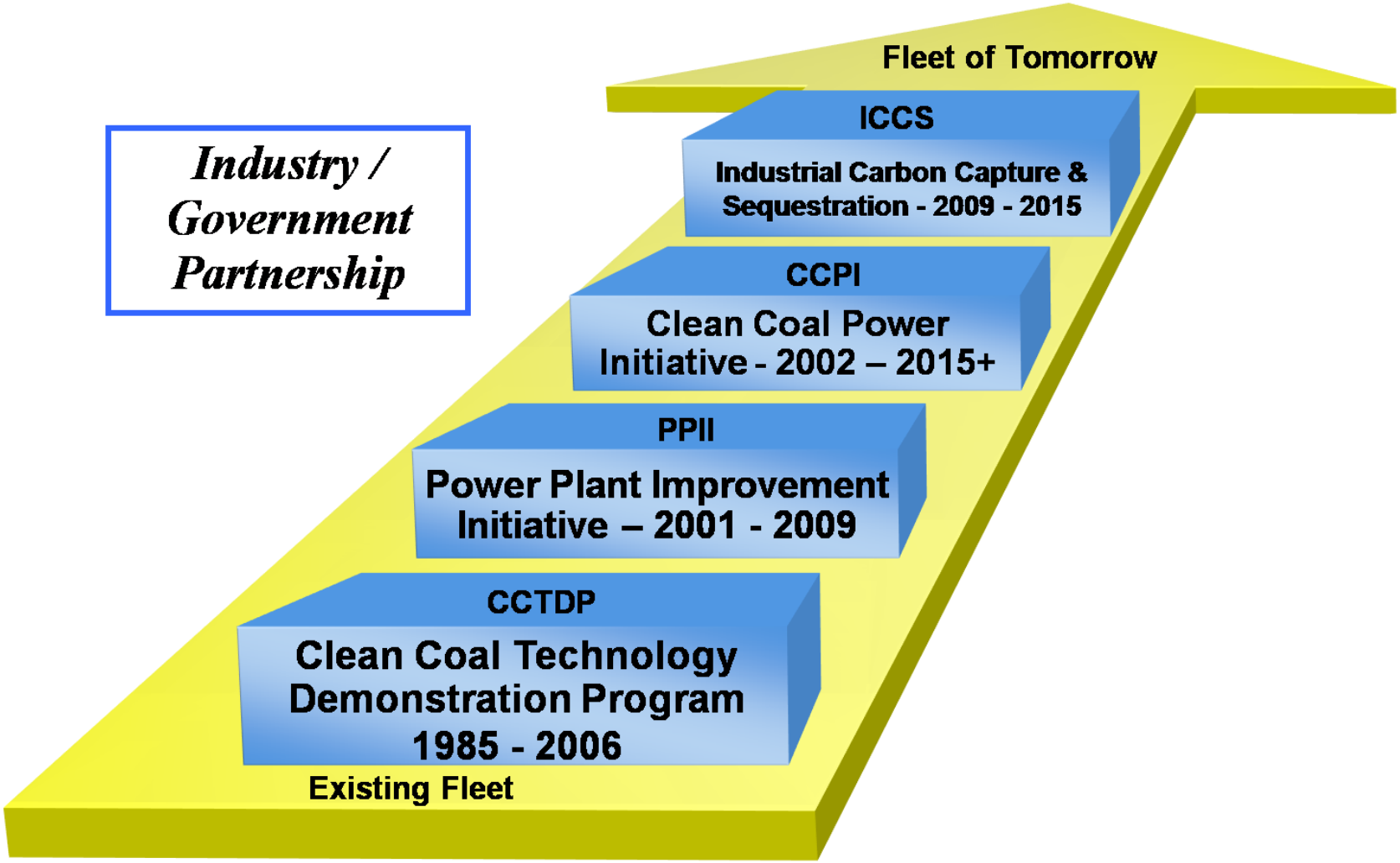
Goals

TECHNOLOGIES & BEST PRACTICES

- < 10% increase COE with CCS (pre-combustion)
- < 35% increase COE with CCS (post- and oxy-combustion)
- < $400/kW fuel cell systems (2002 $)
- > 50% plant efficiency, up to 60% with fuel cells
- > 90% CO_2 capture
- > 99% CO_2 storage permanence
- +/- 30% storage capacity resolution

DOE's Major Demonstrations Program

A History of Innovative Projects



Some Notable Program Successes

Advanced Pollution Controls

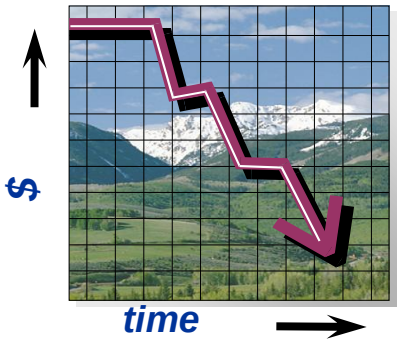
- Installed on 75% of U.S. coal plants
- 1/2 to 1/10 cost of older systems

FGD Scrubbers

Low-NO_x Burners

HAPS & Hg Data

- Quantified HAPS Levels
- Basis for Hg Regulations



Advanced Coal Power Systems

- World's largest CFBC power plant
- Two "super-clean" coal-based IGCC

Tampa IGCC

JEA CFBC

Wabash IGCC

CCT and CCS Demonstrations

A Critical Step for Commercial Deployment

- **CCT and CCS demonstrations reduce technical, economic, and environmental risk or uncertainty for new technology**
  - Provides large-scale experience needed to validate pilot or smaller scale tests at the most cost-effective scale
  - Is essential for securing the multi-billion $$ investment needed for commercial deployment of advanced coal projects
  - Assures regulators and the public that advanced CCT technology is environmentally benign and provides significant public benefit and that CCS can provide safe and permanent carbon storage
- **CCS will only be deployed commercially if:**
  - Carbon reduction is mandated by regulation or carbon emissions are monetized
  - It proves to be cost competitive with other low carbon alternatives (e.g., NGCC, nuclear)
  - Commercial risks are regarded as acceptable

"If we can develop the technology to capture the carbon pollution released by coal, it can create jobs and provide energy well into the future."
President Barack Obama, February 3, 2010

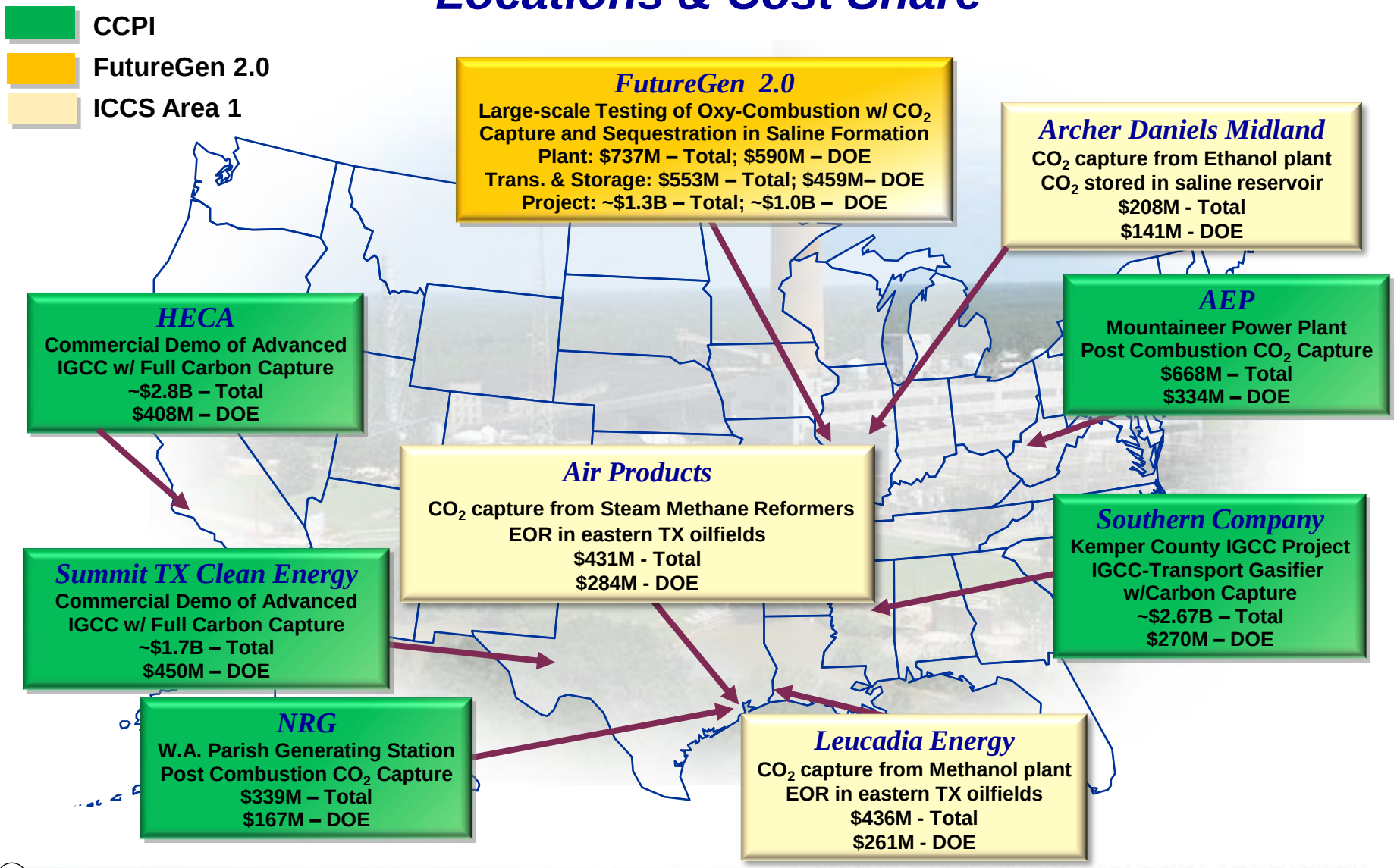
DOE - FE ARRA Demonstration Portfolio

$3.3 Billion Total Funding

Objectives	Programs/FOAs	Results
Demonstrate CCS technology to reduce GHG emissions from electric power and industrial applications	*Clean Coal Power Initiative – Round 3 - $800M added to $600M from the base program*	*4 New CCPI Projects:* *- 2 Back-End CO_2 Capture* *- 2 IGCC*
Promote technology; support economic recovery; produce jobs	*Industrial Carbon Capture & Storage (ICCS) Area 1 - $700 M*	*11 Phase 1 Projects Down-selected to 3 Phase 2 Projects*
Logical extension of FE coal program activities	*Carbon Capture & Storage $1B*	*2 Awards under 1 Project:* *-Ameren Energy: Oxy-combustion* *-FutureGen Alliance: CO_2 Sequestration*

Major CCS Demonstration Projects

Locations & Cost Share



A Portfolio of Capture and Storage Approaches

	Power	Industrial	Saline	EOR	Feedstock
Pre-combustion					
HECA (IGCC-Polygen)	X	X		X	Coal/Coke blend
Southern-Kemper Co. (IGCC)	X			X	Lignite, MS
Summit Texas (IGCC-Polygen)	X	X		X	Coal, sub-bituminous, WY
Leucadia, Lake Charles (Methanol)		X		X	Petroleum coke
Air Products (SMR)		X		X	Natural gas
ADM (Capture from Biofuels)		X	X		Ethanol production from biomass
Post-combustion					
Mountaineer	X		X		Coal, bituminous
NRG Energy	X			X	Coal, sub-bituminous, WY
Oxy-combustion					
FutureGen 2.0	X		X		Coal

= *Today's presentations*

Clean Coal Power Initiative (CCPI)

Clean Coal Power Initiative (CCPI)

- CCPI is a cooperative, cost-shared program between the government and industry which will demonstrate advanced coal-based power generation technologies including carbon capture and storage.

- Demonstration projects represent technologies ready for commercial entry; competitively selected with requirement of at least 50% cost share from industry.

- **CCPI Round III**

Criteria:

Capture and sequester, or put to beneficial reuse, >300,000 TPY of CO_2 emissions

Minimum coal or coal refuse energy input: **55%**

Attain **50%** CO_2 capture efficiency in treated flue gas (target 90%)

5 projects selected July and December 2009

1 selected but not awarded - project de-funded with FY2011 budget rescission

1 project withdrew: Feb 2010; additional project selected March 2010

CCPI Active CCS Projects

CCPI Round	Project	Recipient	CO_2 Capture Technology	Sequestration	CO_2 Seq. TPY	Seq. Start
CCPI-2	Kemper	SCS	Selexol®	EOR	3,000,000	2014
CCPI-3	HECA	HECA	Selexol®	EOR	2,000,000	2018 (est.)
CCPI-3	Mountaineer	AEP	Chilled Ammonia Process	Saline	1,500,000	2015*
CCPI-3	WA Parish	NRG Energy	Fluor Econamine FG Plus℠	EOR	400,000	2014
CCPI-3	TCEP	Summit	Rectisol®	EOR	3,000,000	2014

**Original plan*

W.A. Parish NRG Energy CCPI-3

Advanced Post Combustion CO_2 Capture

- Thompsons, TX (near Houston)
- 60 MWe slipstream at NRG Energy's W.A. Parish power plant
- PRB sub bituminous coal fuel
- 90% CO_2 capture (Fluor's Econamine FG Plus^{SM} process) 400,000 tons CO_2/year
- Texas Gulf Coast EOR (Start: 2014)
- Total Project: $339 Million
  DOE Share: $167 Million (49%)

- Project Awarded: May 2010
- Construction: December 2012
- Operation: December 2014

- Status
  - 60 MWe FEED almost complete
  - Project being scaled up to improve economics
  - Initiated 240 MWe FEED May 3, 2010
  - Negotiations to purchase EOR host site ongoing

Hydrogen Energy California

Advanced IGCC with CO_2 Capture

- Kern County, CA
- ~235 MWe (net) IGCC, 1.0 MT/yr Urea/UAN
- 90% CO_2 capture – 2,500,000 tons CO_2/year
- EOR - Elk Hills oil field (Start: TBD)
- Fuels: Bituminous Coal/Petcoke
- Maximize use of non-potable water for power production
- Recycle all IGCC/project wastewater with 100% zero liquid discharge (ZLD) system
- Total Project ~ $4.0 Billion (DOE - $408 Million)

IGCC Poly-generation with Integrated Carbon Capture & Sequestration

- Project Awarded: 9/30/09
- Project Being Re-baselined

- Status
  - New Owner Closing Anticipated in September 2011

American Electric Power Co. (AEP) CCPI-3

Advanced Post Combustion CO_2 Capture

- New Haven, WV
- 235 MWe slipstream at AEP's 1300 MWe Mountaineer Plant
- 90% CO_2 capture (Alstom Chilled Ammonia Process) 1,500,000 tons CO_2/year
- Deep saline sequestration in the Rose Run and Copper Ridge formations (Start: 2015)
- Total Project: $668 Million DOE Share: $334 Million (50%)
  - $146 Million ARRA
  - $188 Million CCPI

- Project Awarded: January 2010
- FEED Complete: September 2011
- Construction: January 2013
- Operation: December 2015

- Status
  - FEED on schedule (Sept. 2011)
  - NEPA (Draft EIS completed but on hold)
  - Project postponed; Partial termination of Cooperative Agreement

Industrial Carbon Capture & Storage (ICCS)

CO_2 Capture from Industrial Sources

Low Hanging Fruit

- **Globally, industry accounts for 40% of energy-related CO_2 emissions -- mostly in developing countries***
- **Many industrial facilities are large point sources**
- **In some plants, CO_2 already captured to produce desired product (e.g., H_2/NH_3); additional capture cost not incurred**
- **CO_2 concentration in treated stream may be high or nearly pure**
- **Often located near potential storage sites**
- **Demonstration of capture and compression technology, as well as CO_2 storage experience, is applicable to coal-fired power generation**

Hanson Permanente Cement Kiln, Los Altos, CA, 2008

** Global CCS Institute, Klaas van Alphen, 2010, http://www.ieaghg.org/docs/General_Docs/Summer_School/VAN_ALPHEN_-_Industrial_Sources_-_secured.pdf*

Photo Source: kqedquest on flickr - http://www.flickr.com/photos/kqedquest/2388352316/

Industrial Carbon Capture & Storage (ICCS) FOA $700 M for Area 1 Large-Scale CCS

- **Goals and Objectives**
  - Capture 75% of the CO_2 from the treated industrial stream
  - Store 1 million tons of CO_2 in a saline formation or other value-added options (i.e., EOR)
  - Investigate novel CO_2 use / reuse technologies

- **Competitive FOA with Staged Competition**
  - Phase I Project Feasibility/Definition
  - Competitive down-selection after 7 months yielded 3 Phase 2 projects from 11 Phase 1 projects
  - Awarded Phase 2 Full Scope projects Summer 2010
  - 50% cost share targeted

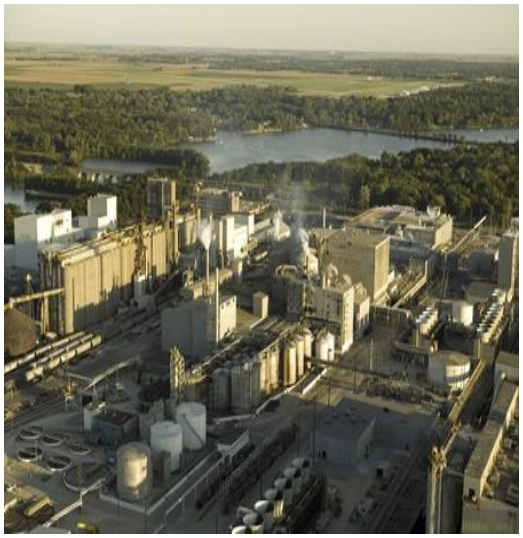
List of ICCS Area 1 Projects – Phase 2

Project	Recipient	CO_2 Capture Technology	Sequestration	CO_2 Seq.TPY	Seq. Start
Fermentation CO_2	ADM	N/A	Saline	1,000,000	2013
SMR H_2 Production	APCI	VSA	EOR	1,000,000	2013
Methanol from Petcoke Gasification	Leucadia Energy, LLC	Rectisol®	EOR	4,500,000	2015

Archer Daniels Midland Company ICCS Area 1

CO_2 Capture from Biofuel Plant

- **Decatur, Illinois**
- **CO_2 is by-product (>99% purity) from production of fuel grade ethanol via anaerobic fermentation**
- **Up to 90% CO_2 capture and compression (1,000,000 tons CO_2/year)**
- **Sequestration in Mt. Simon Sandstone saline reservoir (Start: July 2013)**
- **Total Project: $208 Million**
  DOE Share: $141 Million (68%)



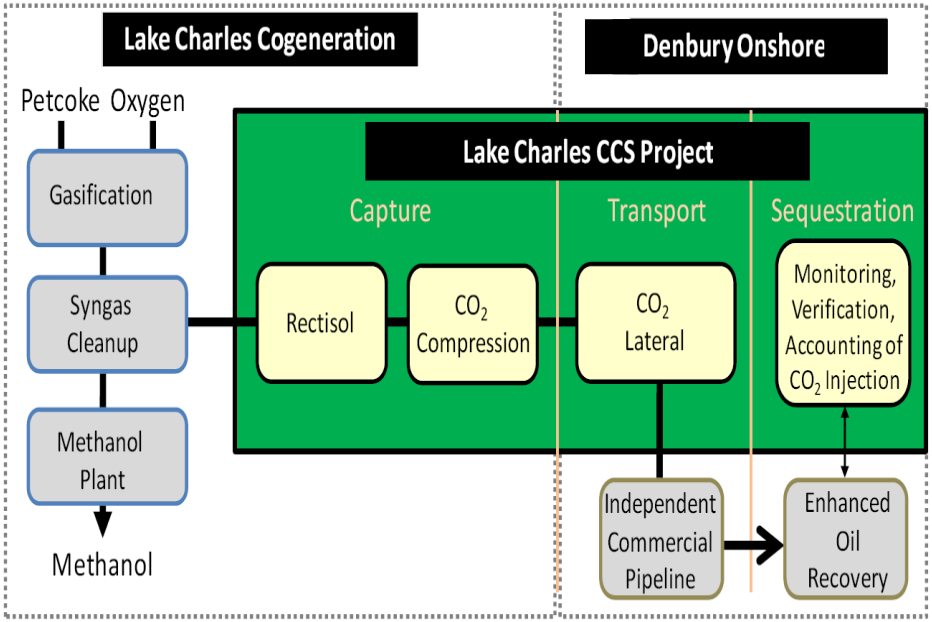
- **Phase 2 Awarded: June 15, 2010**
- **FEED Complete: April 2011**
- **Construction: July 2011**
- **Operation: July 2013**

- **Status**
  - **Detailed design in progress**
  - **NEPA completed**
  - **Site preparation in progress**

Leucadia Energy, LLC ICCS Area 1

Lake Charles CCS Project

- Lake Charles, Louisiana
- GE Energy Gasification (5 gasifiers: 4 hot/1 spare)
- 730 Million gallons/year methanol
- 90% CO_2 capture (Rectisol® process); 4,500,000 tons CO_2/year
- CO_2 to Denbury pipeline for EOR in Texas at the West Hastings oil field (Start 2015)
- Total Project: $436 Million
  DOE Share: $261 Million (60%)

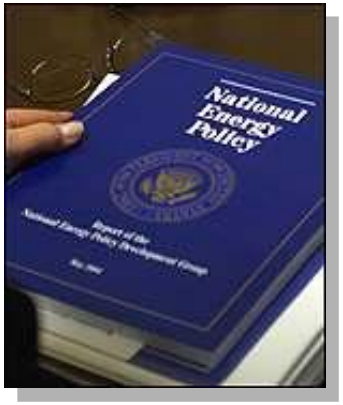


- Phase 2 Awarded: June 17, 2010
- Complete FEED: July 2011
- Construction: October 2012
- Operation: September 2015

- Status
  - FEED completed July 2011
  - NEPA EIS in progress

DOE's Loan Guarantee Program

- **First solicitation — *16 pre-applicants invited to submit applications* (3 fossil energy projects selected) - *October 2008***
- **DOE third round solicitation for $8.0 billion in loan guarantees - *targets innovative clean coal technologies***
  - **Issue Date: September 22, 2008**
  - **Application Received: March 23, 2009**
  - **4 Selections Made: July 2009**



Advanced Fossil Energy Invited Projects
Mesaba Energy Project (MEP–I, LLC): Integrated Gasification Combined Cycle (IGCC) Plant
Mississippi Power Company: Lignite Coal IGCC Plant (Kemper County)
TX Energy, LLC: Coal to Synthetic Gas IGCC Plant
Indiana Gasification, LLC: Coal to Synthetic Natural Gas Plant
Mississippi Gasification, LLC: Pet Coke to Synthetic Natural Gas Plant (Moss Point)
Christian County Generation, LLC: Coal to Synthetic Natural Gas & Power Plant
Medicine Bow Fuel & Power, LLC: Coal to Liquids Plant

For Additional Information

Office of Fossil Energy
www.fe.doe.gov

NETL
www.netl.doe.gov